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Mixing at high Schmidt number in a random array of spheres

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We present experimental results on the mixing of a passive scalar in a flow crossing a random array of spheres. A fluorescent dye having a low molecular diffusivity is injected through a point source in the array (Fig. 1) and we observe by planar laser induced fluorescence the concentration field in a large section transverse to the flow located at different longitudinal positions z from the source. The flow configuration is characterised by a solid volume fraction of 2%, Reynolds numbers of the spheres Re in the range 100 - 1000, a Schmidt number equal to 2000 and a ratio between the injector diameter and that of the spheres equal to 0.1. This study allows us to analyse the fundamental mechanisms controlling the mixing in the turbulence inside the array, which is also representative of the agitation in dispersed flows such as swarms of bubbles¹. Some important results have been obtained about mixing². They show that a transition exists in the mixing around $Re = 400$. For lower Re the main mechanism of mixing is the direct interaction of the filament of dye with the local deformation of the flow in the vicinity of the spheres. At higher Re , the flow being destabilized, turbulence is present in the array and is responsible for the mixing. Our investigations show that one can introduce an effective diffusivity to model the mixing at large distances as compared to the integral length scale (Fig. 2). Moreover, the spatial spectrum of the concentration reveals that the mixing is controlled by different mechanisms depending on the wavenumber range that is considered.

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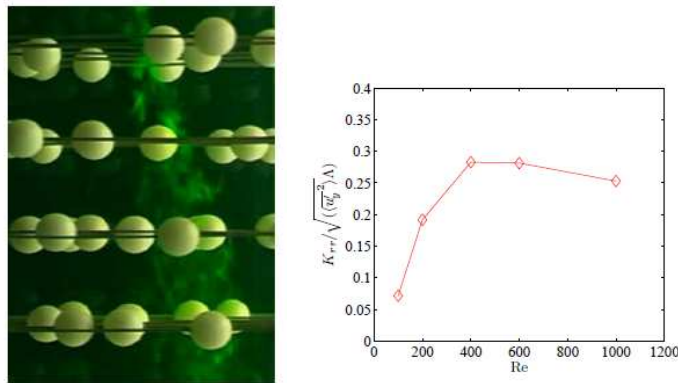


Figure 1: Fig. 1: View of the experiments. Fig. 2: Effective diffusivity in the random array.